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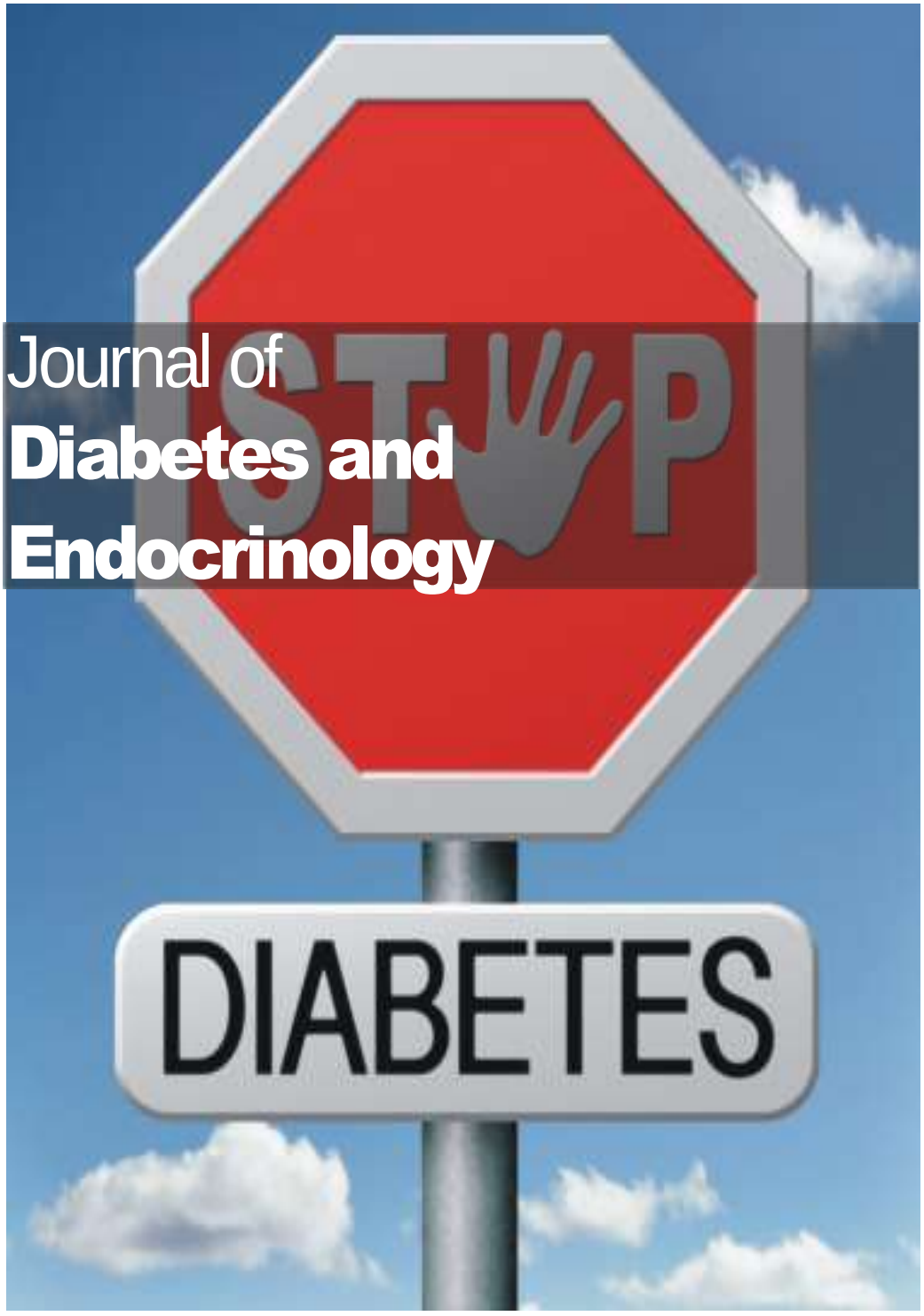

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Full Length Research Paper

Knowledge regarding diabetic complications among diabetic clients attending outpatient department in a tertiary hospital, Kathmandu

Nabina Paneru

Nursing, Maharajgunj Nursing Campus, Kathmandu, Nepal.

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Diabetes, a known medical problem for more than two millennia, provokes complication in many parts of body and increase risk of premature death. Prevalence of diabetes is steadily increasing everywhere, most markedly in the world's low and middle- income countries. Diabetes Mellitus (DM) is a devastating disease but complications of Diabetes Mellitus can be prevented or delayed through proper awareness and preventive measures. The descriptive cross-sectional study was carried out with main objective to find out knowledge regarding diabetic complications among diabetic clients. Using non - probability purposive sampling method, 100 diabetic clients attending medical Out Patient Department of Tribhuvan University Teaching Hospital (TUTH) were selected and data was collected using pretested semi - structured interview schedule. Findings of the study revealed that almost all (90%) respondents had knowledge on major symptoms of hyperglycemia and 82% knew about its immediate management. Regarding hypoglycemia two third (66%) had knowledge on major symptoms of hypoglycemia whereas almost all (92%) had knowledge on its immediate management. Almost all respondents (95%) knew diabetics have increased risk of loss of vision whereas only 13% knew about increase risk of nerve damage. The study showed significant association between knowledge level and educational status (p=0.000), economic status (p=0.008), and participation in diabetes counseling (p=0.005). Based on the findings, it was concluded that respondents' knowledge regarding DM complication is above average. However, there is need of health education on warning symptoms of diabetes complications and their preventive measures.

Key words: Diabetes mellitus, knowledge, diabetes complications.

INTRODUCTION

Diabetes is one of the most common non - communicable diseases of the modern world, affecting 422 million people worldwide and cause an estimated 1.5 million deaths each year. The prevalence of Diabetes Mellitus

E-mail: panerunabina11@gmail.com.

has risen exponentially around the globe in the last 3 decades. Similarly, 108 million people had had Diabetes Mellitus in 1985, the number increased to 422 million by 2016 which is predicted to be doubled by 2030 [World Health Organization (WHO), 2016].

Diabetes is a chronic condition that occurs when the body cannot produce enough insulin or cannot use insulin effectively and is diagnosed by observing raised levels of glucose in the blood. Overtime, hyperglycemia causes damage to many tissues in the body, leading to the development of disabling and life threatening health complications including loss of vision, kidney failure, heart attacks, strokes, leg amputations and heart failure (International Diabetes Federation (IDF), 2016).

In 2015, the International Diabetes Federation's (IDF) Diabetes Atlas estimates that: in high - income countries up to 91% of adults with the disease have type 2 diabetes. Three- quarters (75%) of people with diabetes live in low- and middle - income countries. It is estimated by IDF that 193 million people with diabetes are undiagnosed and are therefore more at risk of developing complications. Furthermore, one in 15 adults is estimated to have impaired glucose tolerance, and one in seven births is affected by gestational diabetes. Both of these conditions are associated with an increased risk of developing type 2 diabetes in later life. Similarly, 215.2 male populations and 199.5 million female populations worldwide are estimated to have diabetes.

According to WHO - Diabetes country profiles 2016, Diabetes in Nepal is the 7th leading cause of death. About 3% of total mortality ratio died because of diabetes. Prevalence of diabetes increased from 4.7% in the year 1980 to 9.5% in the year 2016. Similarly, 1270 males and 1080 females of age group 30 - 69 and 1370 male and 1430 females of age group 70+ died due to diabetes in the year 2016. Above 20 years of age, 14.6% of people residing in urban area and 2.5% of people in rural areas are suffering from diabetes. Prevalence of type 2 diabetes in urban and rural populations was 8.1 and 1.0% respectively [Nepal Diabetes Association (NDA), 2016].

The prevalence of diabetes is steadily increasing everywhere; most markedly in the worlds middle-income countries. Unfortunately, in many settings the lack of effective policies to create supportive environments for healthy lifestyles and the lack of access to quality health care means, prevention and treatment of diabetes are not being pursued. When diabetes is uncontrolled, it and its complications have dire consequences for health and wellbeing, finances of individuals and their families, and the economies of nations. Lack of awareness about diabetes, its complications combined with insufficient access to health services and essential medicines leads to complications such as blindness, amputation, heart disease and kidney failure (Diabetes facts WHO, 2016).

According to WHO Global Report on Diabetes (2016), prevalence of retinopathy in diabetic clients is 35%. Retinopathy causes 1.9% of moderate to severe vision loss. Prevalence of End Stage Renal Disease in diabetic client is 12 to 55%. Similarly, prevalence of cardiovascular events and lower extremity amputation is 2 to 3 times and 10 to 20 times higher in diabetic patients than non-diabetic patients respectively.

In a study carried out in Peshawar, Pakistan, out of 96 diabetic clients 76 of the patients were illiterate; 36 (37.5%) had good, 24 (25%) had average and 36 (37.5%) had poor knowledge. Between 50-60% patients were aware of different cardiac complications of diabetes mellitus. Awareness regarding other complications was foot ulcer 70 (72.91%), poor wound healing 68 (70.83%), stroke 54 (56.25%), renal disease 64 (66.66%), eye disease 53 (55.20%), hypoglycemia 50 (52.08%) and symptoms of diabetic neuropathy ranging from 47 to 65% (Ullah et al., 2015).

A descriptive study carried out in diabetic clients visiting the diabetic clinic at Sampa Government Hospital, Ghana, out of 630 participants, 325 (51.5%) knew diabetic foot as the most common complication followed by hypertension 223 (35.4%), neuropathy 184 (29.2%), eye disease 112 (17.7%), heart disease 58 (9.2%), and renal disease 34 (5.4%). Comprehensive assessment of level of knowledge on the complications showed that majority 378 (60.0%) of type 2 DM patients did not have knowledge on diabetic complications, 169 (26.9%) had inadequate knowledge on diabetic complication while 82 (13.1%) had adequate knowledge (Obirikorang et al., 2016).

According to the descriptive study conducted among the 100 diabetic out-patients of B.P.Koirala Institute of Health Sciences, Dharan, the most common and frequent chronic diabetic complications were neuropathy (44.4%) followed by cardiovascular (11.9%), retinopathy (19.04%), nephropathy (16.6%) and others (11.3%) in the year 2011 (Maskey et al., 2011).

Diabetes Mellitus is one of the major fast growing non-communicable disease (NCD) threats to global public health. Trends in the incidence of diabetes indicate a disproportionate increase in developing countries due to current rapid demographic transitions from traditional to more westernized and urbanized lifestyles. It is on rise because of whether people they do not have knowledge on diabetic complications or they are neglecting the disease condition. Few studies have been carried out in Nepal in the past years, hence the researcher’s desire to study this topic.

The objective of the study was to find out knowledge on complications of diabetes between type 2 diabetic clients attending medical OPD and Diabetic clinic of TUTH.

MATERIALS AND METHODS

The descriptive cross sectional study was conducted in medical outpatient department and diabetic clinic of Tribhuvan University Teaching Hospital, Kathmandu over a period of 2 weeks including 100 patients. Sample was selected using non-probability purposive sampling technique. Sample size was calculated using formula

($n=Z^2pq/ e^2$) taking 62.5% prevalence of knowledge on diabetic complications reported by Ullah et al. (2005) 95% confidence level and 10% absolute precision). All the clients of both sex (male and female) diagnosed with type 2 DM for more than 3 months attending medical OPD and diabetic clinic of TUTH and those willing to participate in the study were included. Data was collected by semi-structured interview schedule. All participants were asked 17 close-ended questions and they were categorized as good and poor from mean score. All the data were reviewed, organized, and coded. Coded data was entered in datasheet and was analyzed by using descriptive statistics (frequency, percentage, mean and standard deviation) and chi square test was used to find out association between knowledge level and selected socio-demographic variables.

RESULTS

In this study, 100 participants were included, among them 59% were female and 41% were male. Fifty percent of the participants were of age group 40 to 59 years with mean age of 48.49±12.54. Descriptive statistics of the study population, the distribution of age group, sex, educational status, occupation, economic status, family history of DM, and duration of DM are shown in Table 1. Knowledge regarding short term and long-term complications of diabetes shown in Table 2 and Table 3 shows cross tabulation: level of knowledge and selected socio-demographic variables. About 95% of the participants said they got knowledge on diabetic complications from health institutions. With respect to knowledge about complications of DM, 51% had good knowledge and 49% had poor knowledge (Table 4).

DISCUSSION

This study reveals that regarding source of information, almost all (95%) of the respondents obtained information about diabetes and its complication from health personnel followed by friends and family. Supporting this result, a research conducted by Menezes et al. (2015), of 100 samples, majority (78%) came to know the information from physician and rest from other different sources.

Regarding knowledge on meaning of diabetes, 56% thought that diabetes is a disease condition in which blood sugar is increased than normal level. Supporting this finding, of 199 patients in a research conducted by Foma et al. (2013) in Gambia, 47% said they knew what diabetes is.

This study shows that 62% of the respondents had knowledge to check blood sugar level monthly in case of uncontrolled DM. Similar to this finding study done by Dinesh et al. (2017), showed that out of 400 samples, 65% of the study participants had knowledge to check their blood sugar monthly. Regarding symptoms of hyperglycemia, almost all (90%) knew about excessive urination and excessive thirst as the major symptoms. Majority (82%) of them consult physician when these sign occurs. Supporting this finding, a research conducted by Mammen and Thankachan (2017), of 100 patients, majority 58% told that frequent urination and excessive thirst are symptoms of hyperglycemia and they seek physicians help when these signs occur.

Majority (74%) had knowledge on the symptoms of hypoglycemia but almost all 92% of them told that taking chocolate/sugar products immediately when symptoms of hypoglycemia occur. Supporting this finding, research conducted by Mammen and Thankachan (2017), of 100 patient only 40% knew the symptoms of hypoglycemia but 74% told that they knew sweets should be consumed when there is hypoglycemic episode.

This study revealed that almost all (95%) knew that diabetic people have higher risk of loss of vision and 81% knew there is increased risk of hypertension followed by increased risk of kidney failure (76%), increased risk of lower limb amputation (72%), increased risk of cardiac problems (68%), increased risk of stroke (38%) and increased risk of nerve damage (13%). There was similarity in a research conducted by Deepali et al. (2017) where out of 120 diabetics, 94.7% knew that diabetes could lead to retinopathy, 90.4% knew that kidneys can also be affected followed by heart problems 64.5%, nerve damage 68.4%. A study done on Malaysia conducted by Qureshi et al. (2014) also demonstrated that 63.5% of diabetics knew that it could lead to loss of sensation in arms and legs.

Regarding knowledge level on diabetes complication, this study showed 51% of the participants had good level of knowledge. Supporting this finding, a research conducted by Deepali et al. (2017) showed that 55.8% out of 120 diabetics had knowledge on diabetes and its complications. A cross tabulation of socio - demographic characteristics of respondents and their knowledge level showed significant association between knowledge level and educational status (P=0.000), knowledge level and economic status (P=0.008). Supporting this finding, research conducted in Sampa Government Hospital, Ghana, of total 630 participants study showed that there is significant association between knowledge level and education status and knowledge level and economic status (Obirikorang et al., 2016).

This study showed significant association between knowledge and participation in diabetes counseling (P=0.005). Supporting this finding, research conducted by Deepali et al. (2017) knowledge level of people participated in diabetes awareness program was significantly higher. This study showed there is no significant association between family history of DM and knowledge on diabetes complication, which was contradictory to findings of research conducted in Gambia by Foma et al., which showed that history of diabetes in 1st degree relatives, have positive impact on diabetes knowledge.

In other researches, age, sex, occupation and duration of diabetes were found to be positively associated with

Table 1. Socio-demographic characteristics of the participants.

Characteristics	Percentage
Age	
20 – 39 years	27
40 – 59 years	50
60 years and above	23
Mean Age = 48.49±12.54	
Sex	
Female	59
Male	41
Educational Status:	
Unable to read and write	22
Able to read and write	78
Occupation	
Homemaker	48
Service	26
Agriculture	10
Business	9
Retired	5
Labor	2
Economic Status	
Sufficient for less than 6 months	23
Sufficient for 6 months	22
Sufficient for 1 years	41
Sufficient for 1 years with surplus	14
Family History of DM	
Yes	30
No	70
Duration of Diabetes	
3 months - 1 years	31
More than 1 years	69
Mean duration = 3.7 years	
Participation in Diabetes Counselling	
Yes	34
No	66

more knowledge but it is not consistent with the current study.

LIMITATIONS

This study was conducted in the Out Patient Department and Diabetic Clinic of TUTH with small sample size and data collection was done by purposive sampling technique, using interview method. Therefore, the findings of the study cannot be generalized.

Conclusion

The findings revealed that there was a good knowledge on symptoms and management of hypo and hyperglycemia, complications of DM, and its preventive measures; while only few of them had knowledge regarding warning symptoms of long-term complications

Table 2. Respondents' sources of information on knowledge regarding DM.

Sources of information*	Percentage
Health Institutions	95
Newspaper/Magazine/Pamphlet	24
TV/Internet	23
Course Books	13
Friends	13
Family	1

* Multiple choice.

Table 3. Knowledge about short-term and long-term complications of DM.

Responses	Percentage	
	Yes	No/Do not know
Knowledge on Meaning of DM	56	44
Knowledge on Symptoms of Hyperglycemia*		
Excessive urination	90	10
Excessive thirst	90	10
Dry mouth	65	35
Loss of vision	48	52
Sleepiness and confusion	45	55
Headache	40	60
Warm, dry skin that does not sweat	13	87
Knowledge on Immediate Management of Hyperglycemia	82	18
Knowledge on Symptoms of Hypoglycemia*		
Confusion and drowsiness	66	34
Sweating and tremor	53	47
Palpitations	45	55
Disorientation and loss of consciousness	29	71
Hunger	22	78
Slurred speech	18	82
Double vision	10	90
Knowledge on Immediate Management of Hypoglycemia	92	8
Increase risk of loss of vision	95	5
Increase risk of hypertension	81	19
Increase risk of kidney failure	76	24
Increase risk of lower limb amputation	72	28
Increase risk of cardiac problems	68	32
Increase risk of stroke	38	62
Increase risk of nerve damage	13	87

*Multiple choice.

and risk of nerve damage. Those who were able to read and write, economic status sufficient for 1 year and surplus, and those who had participated in diabetes counseling had higher level of knowledge. The overall level of knowledge regarding diabetes complications among diabetic clients is good.

Table 4. Cross tabulation: Association between knowledge level and selected socio-demographic variables.

Variable	Level of Knowledge		Chi Square	P Value
	Good	Poor		
Age				
20 - 39 years	13	14	2.378	0.304
40 - 59 years	29	21		
60 years and above	9	14		
Sex				
Female	27	32	1.579	0.209
Male	24	17		
Educational Status				
Able to read and write	47	31	12.156	0.000
Unable to read and write	4	18		
Occupation				
Homemaker	20	28	9.924	0.077
Service	17	9		
Agriculture	4	6		
Business	6	3		
Retired	4	1		
Labor	0	2		
Economic Status				
Sufficient for less than 6 months	7	16	11.709	0.008
Sufficient for 6 months	12	10		
Sufficient for 1 years	20	21		
Sufficient for 1 years with surplus	12	2		
Family History of DM				
Yes	19	11	2.609	0.106
No	32	38		
Duration of Diabetes				
3 months - 1 years	15	16	0.123	0.726
More than 1 years	36	33		
Participation in Diabetes Counseling				
Yes	24	10	7.910	0.005
No	27	39		

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Antihyperglycaemic effect of aqueous extract of *Moringa oleifera* leaf on alloxan-induced diabetic male Wistar rats

Ebenezer Abimbola Morolahun*, Senga Kali Pemba and Cassian Celestine

[1]Department of Human Physiology, Faculty of Medicine, St Francis University College of Health and Allied Sciences, Ifakara, Tanzania.
[2] Department of Public Health, Faculty of Medicine, St Francis University College of Health and Allied Sciences, Ifakara, Tanzania.
[3] Department of Human Anatomy, Faculty of Medicine, St Francis University College of Health and Allied Sciences, Ifakara, Tanzania.

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This research was designed to investigate antihyperglycaemic impact of aqueous extract of *Moringa oleifera* leaf on alloxan-induced diabetic male wistar rats. Diabetes is a metabolic disease linked to weakened sugar metabolism. Managing diabetes devoid of any adverse effect remains an issue to health system. Therefore, there is an increase in the search for better anti-diabetic medicine. *M. oleifera* leaves were air-dried, grinded, sieved and the aqueous extract was prepared. Twenty male wistar rats were used and these rats were grouped into four groups, five rats in each group. Group 1 and group 2 rats were diabetes induced groups treated with 100 and 400 mg/kg of aqueous extract of *M. oleifera* leaf respectively, group 3-diabetic untreated group, group 4-control group. Fasting blood glucose level, uric acid level and C-reactive protein level were measured by oxidase method, Uricase-PAP method and turbilatex method respectively. Results of this research work showed a significant increase in the fasting blood glucose level, uric acid level and C-reactive protein level in rats that were diabetic when compared with the control rats. However, treatment with 100 and 400 mg/kg of aqueous extract of *M. oleifera* leaf for a period of four weeks brought the fasting blood glucose level, uric acid level and C-reactive protein level toward the basal level significantly (P<0.05). The study showed that the aqueous extract of *M. oleifera* leaf has the potential to lower the elevated fasting blood glucose, uric acid and C-reactive protein levels toward the basal level in alloxan-induced diabetic male Wistar rats.

Key words: Hyperglycaemia, *Moringa oleifera* leaf, fasting blood glucose, uric acid, C-reactive protein, health system, metabolic disease.

INTRODUCTION

Diabetes mellitus (DM) is a multifactorial disease which is characterized by hyperglycaemia, lipoprotein abnormalities (Scoppola et al., 2001) and altered intermediary metabolism of major food substances (Unwin et al.,

*Corresponding author. E-mail: emorolahun@sfuchas.ac.tz.

2001).

Three major types of diabetes mellitus (DM) exist. Type 1 diabetes mellitus results from the inability of the body to generate insulin and is required of the individual to inject insulin or wear an insulin pump (Amed and Oram, 2016). This form was formerly known as insulin- dependent diabetes mellitus. Type 2 diabetes mellitus results from insulin resistance, a situation where the cells of the body cannot utilize insulin well, occasionally joined with total deficiency of insulin. This was formerly called non- insulin dependent diabetes mellitus. The third major type of diabetes mellitus is gestational diabetes; it happens when pregnant women who have no past history of diabetes start developing high level of blood sugar. Other forms of diabetes mellitus include congenital diabetes, which is due to genetic defects of insulin secretion, cystic fibrosis-related diabetes, steroid diabetes induced by high doses of glucocorticoids, and several forms of monogenic diabetes. Diabetes can be managed by exercise, diet and pharmaceutical drugs which are either too expensive or have undesirable side effects or contraindications (Seuring, 2015). Types 1 and 2 are critical incurable conditions. Pancreas transplantation has been attempted with narrow accomplishment in type 1 diabetes mellitus, and gastric bypass surgery has been successful in many with morbid obesity and type 2 diabetes mellitus. Gestational diabetes usually resolves after delivery. Diabetes without proper management can cause many complications. Acute complications include hypo-glycaemia, diabetic ketoacidosis, or nonketotic hyperosmolar coma. Serious long- term complications include cardiovascular disease, chronic renal failure and diabetic retinopathy. Adequate management of diabetes is thus important as well as blood pressure control and lifestyle factors such as smoking and maintaining a healthy body weight (Lambert and Bingley, 2002).

The pathogenesis of diabetes mellitus and the possibility of its management by existing therapeutic agents without any side effects have stimulated great interest in recent years (Bailey, 1999). Management of diabetes without any side effects is still a challenge for the health care system. Therefore, there is an increased search for improved anti- diabetic drugs.

Few plant extracts used in traditional medicine for treating diabetes have received scientific scrutiny and the World Health Organization has recommended greater attention to the use of plant extracts (WHO, 1980). The present study was carried out to evaluate the anti-diabetic effect of aqueous extract of *Moringa oleifera* leaf in alloxan- induced diabetic male Wistar rats. *M. oleifera* is the most widely cultivated species of the genus Moringa, which is the only genus in the family Moringaceae. Its English common names include moringa, benzolive tree and West Indian ben (Makkar et al., 2007). The tree itself is rather slender, with drooping branches that grow to approximately 10 m in height. In cultivation, it is often cut back annually to 1- 2 m and allowed to re-grow so the pods and leaves remain within arm's reach.

MATERIALS AND METHODS

Plant material

M. oleifera leaves were collected from the University Farm of Ladoke Akintola University of Technology, Ogbomoso of Oyo State. Identification was done at the Department of Biology (Botany option) of the Ladoke Akintola University of Technology, Ogbomoso. The leaves were dried at room temperature until they were free from moisture. The dried leaves were thoroughly grinded into powdery form using mortar and pestle and sieved. And the aqueous extract of *M. oleifera* leaf was prepared by dissolving ten grams of the powder in 40 ml of distilled water as crude extract.

Animals

Wistar rats weighing 100-120 g were used in this research work. The animals were maintained under laboratory conditions of humidity, temperature (23-25°C) and light 12 h light-dark cycle in the Animal House of College of Health Sciences, University of Ilorin, and allowed free accesses to grower mash and water *ad libitum*. The animals were acclimatized for two weeks. The principles of laboratory animal care guideline procedures were followed in the study (NIH publication revised, 1985).

Induction of diabetes

After fasting the animals for 12 h, the animals were given a single dose of intraperitoneal injection of freshly prepared alloxan solution using saline (0.9% (w/v) NaCl) as vehicle at a dose of 12 mg alloxan/100 g body weight (Bahnak and Gold, 1982). The rats were maintained on 5% glucose solution for next 24 h to prevent hypoglycaemia. The diabetic state was ascertained by high fasting blood glucose level above the normal. Symptoms of diabetes were observed within a week of alloxan injection.

Experimental design

Twenty male Wistar rats were used for this study. The rats were divided into four groups, each group consisting of five rats: Group 1, Diabetes induced group treated with 100 mg/kg of aqueous extract of *M. oleifera* leaf; Group 2, Diabetes induced group treated with 400 mg/kg of aqueous extract of *M. oleifera* leaf; Group 3, Diabetes induced untreated group and Group 4, Control group

Determination of fasting blood glucose level

Blood glucose levels were determined using a glucometer (Accu Chek Active) and test strips using glucose oxidase method (Sera Pak, USA).

Determination of uric acid level (Uricase PAP method)

Uricase transforms uric acid in the sample into Allantoin, Carbon dioxide (CO_2) and Hydrogen peroxide (H_2O_2). By the action of Peroxidase (POD) and in the presence of phenol-derivative, DHBS (3,5-Dichloro-2- hidroxy-benzenesulfonic acid) and 4-aminoantipyrine, hydrogen peroxide give a coloured indicator

reaction which can be measured at 520 nm. The increase in absorbance is proportional to the uric acid concentration of the sample (Fossati et al., 1980).

Uricase- PAP methodology: Linear up to 25 mg/dl, reconstituted reagent stable up to 30 days at 2-8°C.

Enzymatic determination of uric acid according to the following reactions;

$$\text{Uric acid} + 2H_2O \xrightarrow{\text{uricase}} \text{Allontoine} + CO_2 + H_2O_2$$

$$2H_2O_2 + \text{4-Aminoantipyrine} + \text{DHBS} \xrightarrow{\text{peroxidase}} \text{Red quinine} + H_2O + HCL$$

DHBS=3.5-Dichloro-2-Hydroxybenzenesulfonic acid.

Uric acid concentration (mg/dl) =Absorbance of sample/Absorbance of standard×6

Determination of C-reactive protein level

The reagent CRP-Turbilatex agglutination assay is a quantitative turbidimetric assay for measuring CRP in serum/plasma. Latex particles coated with specific anti-CRP are agglutinated when mixed with sample containing CRP. The agglutination causes an absorbance change, depending on the CRP contents of the sample that can be quantified by comparison from a calibrator of known CRP concentration (Sindhu et al., 2011). Turbilatex method with high sensitivity and specificity was used. The linear measurement was up to 150 mg/l.

CRP Concentration in mg/l= $(A_2\text{-}A_1)$ sample/ $(A_2\text{-}A_1)$ calibrator × calibrator concentration

Duration of treatment

Treatment started on the day the diabetic state was ascertained. Fasting blood glucose level was determined weekly for 4 weeks throughout the period of the experiment. The animals were then sacrificed using anaesthesia (chloroform) and blood samples were collected from the heart for biochemical analysis.

Analyses

Blood samples collected through cardiac puncture were used to analyze for Uric acid and C-reactive protein concentrations.

Statistical analysis

All values were expressed as Mean±SEM. The differences were compared using one-way Analysis of Variance (ANOVA) followed by student t-test. P values with <0.05 were considered as statistically significant.

RESULTS

Fasting blood glucose levels increased significantly ($P<0.05$) 48 h after the induction of diabetes. But the fasting blood glucose levels were reduced toward the basal level by the aqueous extract of *M. oleifera* leaf significantly ($P<0.05$) (Table 1).

Concentrations of plasma uric acid were significantly reduced toward the basal level ($P<0.05$) by the aqueous extract of *M. oleifera* leaf (Table 2).

The aqueous extract of *M. oleifera* leaf reduced the concentration of C-reactive protein significantly toward the basal level ($P<0.05$) (Table 3).

DISCUSSION

Diabetes mellitus is a metabolic ailment linked to weakened glucose metabolism (Talloroth et al., 1990). Diabetes mellitus can be diagnosed by demonstrating any of the following; fasting plasma glucose level at or above 126 mg/dl (7.0 mmol/l), plasma glucose level at or above 200 mg/dl (11.1 mmol/l) 2 h after a 75 g oral glucose load as in a glucose tolerance test, random plasma glucose at or above 200 mg/dl (Sacks et al., 2011). According to the current definition, two fasting glucose measurements above 126 mg/dl (7.0 mmol/l) are considered diagnostic for diabetes mellitus. Alloxan induces diabetes by damaging the insulin secreting cells of the pancreas leading to hyperglycaemia (Szudelski, 2001). Alloxan, a β-cytotoxin destroys the β-cells of the islets of Langerhans of pancreas (Tyrberg and Anderson, 2001). This leads to a decrease in the endogenous insulin secretion and creates the ways for the decreased utilization of glucose by the tissue. This now results in elevation of blood glucose level above the normal physiological range.

In the present study, the anti-diabetic activity of the aqueous extract of *M. oleifera* leaf was evaluated in alloxan-induced diabetic male Wistar rats, using fasting blood glucose test. Expression of elevated fasting blood glucose level above the normal physiological range confirmed induction of diabetes in alloxan-induced experimental rats. Blood samples collected from the tail of the Wistar rats were used to determine the fasting blood glucose levels weekly throughout the period of the experiment. The glucose levels of the diabetic wistar rats treated with 100 mg/kg of the aqueous extract of *M. oleifera* leaf were lowered toward the basal levels significantly ($P<0.05$). Also, there was a significant decrease in the fasting blood glucose levels of the diabetic wistar rats treated with 400 mg/kg of the same extract ($P<0.05$). This agrees with the local uses of the leaves of the plant for the treatment of diabetes by traditional medicine practitioners. Therefore, this suggests the effectiveness of the aqueous extract of *M. oleifera* leaf in lowering the elevated fasting blood glucose levels in alloxan-induced diabetic rats as shown in Table 1.

The experiment lasted for four weeks after which the rats were sacrificed using chloroform, an anaesthesia

Table 1. Fasting blood glucose (FBG) levels (mg/dl).

Group	FBG prior alloxan induction	FBG after alloxan induction	FBG after 7 days of treatment	FBG after 14 days of treatment	FBG after 21 days of treatment	FBG after 28 days of treatment
Diabetes induced group+100 mg/kg of aqueous extract of *Moringa oleifera* leaf	89.60±5.82*	364.40±6.90	307.20±5.30*	277.60±5.10*	213.40±4.41*	125.80±2.58
Diabetes induced group+400 mg/kg of aqueous extract of *Moringa oleifera* leaf	83.20±3.85*	308.00±5.40*	274.20±4.30*	232.40±4.80	186.40±3.96*	123.20±2.52*

Values are given as Mean±SEM (n=5: number of animals per group). Significant difference *P<0.05.

Table 2. Plasma uric acid levels (mg/dl).

Group	Uric acid (mg/dl)
1: Diabetes induced group+100mg/kg of aqueous extract of *Moringa oleifera* leaf	4.37±1.10*
2: Diabetes induced group+ 400mg/kg of aqueous extract of *Moringa oleifera* leaf	4.11±0.56*
3: Diabetes induced untreated group	6.62±0.70*
4: Control group	3.67±0.25

Concentrations of plasma uric acid were significantly reduced toward the basal level (P<0.05) by the aqueous extract of *Moringa oleifera* leaf. Values are given as Mean±SEM (n=5: number of animals per group). Significant difference* P<0.05.

Table 3. Plasma C-reactive protein levels (mg/l).

Group	C-reactive protein (mg/l)
1: Diabetes induced group+100mg/kg of aqueous extract of *Moringa oleifera* leaf	10.16±1.26*
2: Diabetes induced group+400mg/kg of aqueous extract of *Moringa oleifera* leaf	6.92±1.00*
3: Diabetes induced untreated group	6.27±1.20*
4: Control group	5.53±0.25

Values are given as Mean ± SEM, (n=5: number of animals per group). Significant difference* P<0.05.

and the blood samples were collected from the heart. Uric acid level was measured using Uricase- PAP method which is known to be sensitive and specific. Uric acid is the end product of purine metabolism and its normal physiological range is 3.6-8.3 mg/dl (Doring et al., 2008). Uric acid concentrations in blood plasma above and below the normal range are known as hyperuricemia and hypouricemia respectively and uric acid is being excreted by the kidneys. Increased levels of uric acid are found in gout, arthritis, impaired renal functions and starvation but decreased levels are found in yellow atrophy of the liver. High level of uric acid has been observed to be a risk factor for diabetes (Nakagawa et al., 2006). Hyperuricemia is associated with components of metabolic syndrome. A study has even suggested that fructose-induced hyperuricemia may play a pathogenic role in the metabolic syndrome (Nakagawa et al., 2006). In this study the uric acid level in diabetic rats treated with 100 mg/kg of the aqueous extract of *M. oleifera* leaf was reduced toward the basal level significantly (P<0.05). The same reduction toward the basal level was observed in diabetic rats treated with 400 mg/kg of the same extract.

C-reactive protein level was also estimated using turbilatex method with high sensitivity and specificity and this method can measure up to 150 mg/l of plasma C-reactive protein level. C-reactive protein is an acute protein synthesized by the liver in response to tissue injuries, bacterial and viral infections, inflammation and neoplasia. It is a member of the pentraxin family of proteins (Pepys and Hirschfield, 2003). High level of C-reactive protein level above the normal physiological range has been observed to be an independent risk factor for diabetes, cardiovascular disease such as hypertension (Dehghan et al., 2007). In this study, C-

reactive protein level of the diabetic rats treated with 100 mg/kg of the aqueous extract of *M. oleifera* leaf was significantly reduced toward the basal level ($P<0.05$). The same reduction toward the basal level was observed in diabetic rats treated with 400 mg/kg of the same extract.

Mode of action by which aqueous extract of *M. oleifera* leaf brings about its hypoglycaemic effect may be by potentiating the insulin effect by increasing the insulin secretion from the beta cells of the pancreas. This study showed that aqueous extract of *M. oleifera* leaf has anti-diabetic effect on alloxan-induced diabetic male Wistar rats.

Further work could be done to investigate the active compounds responsible for the observed effect.

Conclusion

In conclusion, this study showed that the aqueous extract of *M. oleifera* leaf has antidiabetic effect. Few plants with potential therapeutic constituents such as fibers, sterols, saponins, polyphenols, flavonoids etc have been investigated for their antihyperlipidemic, antioxidant and antiatheroscelorotic properties. Thus, the phytochemical screening showed the presence of some substances such as alkaloids, saponins, tannis etc in the *M. oleifera* leaf. Further research may be carried out to investigate the exact constituents responsible for the observed effect.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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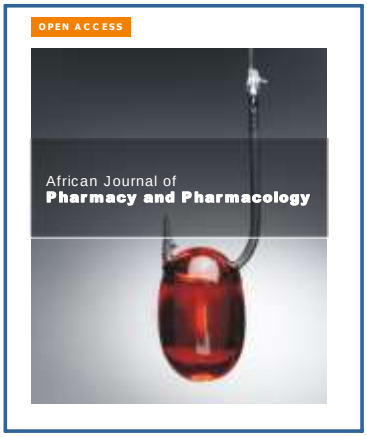

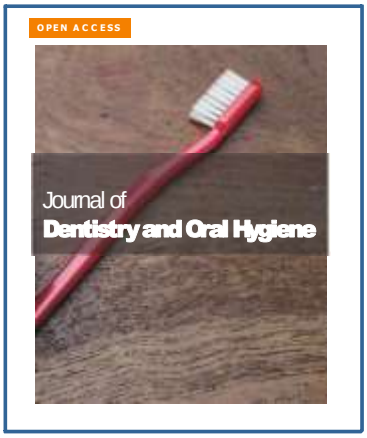

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